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By

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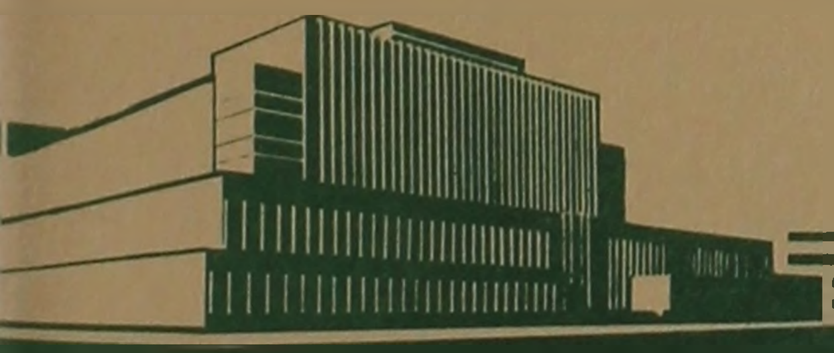

FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

EXPLORATORY KRAFT AND NSSC PULPING AND PRODUCTION OF A BLEACHED, MARKET-GRADE, KRAFT PULP FROM COLOMBIAN HARDWOOD MIXTURES

By

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Summary

Kraft pulps, with quality equal to or better than those of North American hardwood kraft pulps, were made using 3 mixtures of 17 Colombian hardwood species. The concept of using a high-yield kraft process to produce 25 to 30 percent screenings for use in corrugating medium and the screened pulp for linerboard was verified as being feasible. Semi-chemical kraft pulp, with a Kappa number equal to that of the kraft screenings, had handsheet properties comparable to those of the kraft screenings. Handsheet tests indicate that acceptable quality corrugating medium can be made from all three mixtures cooked by the neutral sulfite semichemical (NSSC) process. Improved handsheet quality can be obtained by the addition of caustic soda to the NSSC pulping liquor and/or by reducing the pulp yield. Semichemical kraft and green liquor pulps at 73 percent yield are deficient in the handsheet properties considered essential for the production of acceptable quality corrugating medium.

1/ Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Log Processing and Makeup of Mixtures

Eighteen different species, with a total dry weight of about 8,000 pounds, were harvested in Colombia. This wood resource, covering a range of densities and colors, was received by the Forest Products Laboratory (FPL) in August 1976. Upon receipt, the identification of each species was verified. A 1-foot length was cut from the butt log of each species to provide material for botanical studies, and 1-inch disks were cut from each log for the determination of specific gravity.

All logs were peeled and converted into nominal 5/8-inch chips, keeping each individual species separate. The bark was used in another study to determine calorific value and other potential uses. The chips were screened, and the amounts of oversize (+1-1/4 inches) and undersize (-1/4 inch) were determined. Samples of chips from each species were analyzed for ash and silica. For exploratory kraft and NSSC digestions, mixtures of the screened chips were made to simulate three potential naturally occurring density distributions. Chemical analyses were made on samples of the three mixtures to determine ash, silica, pH, lignin, and extractives. For pilot-scale kraft digestions, a larger quantity of only mixture A was made. Small quantities of three additional mixtures were also made to determine the effect of adding increasing amounts of caustic soda to NSSC cooking liquors as the density of the woods in the mixtures increased.

Exploratory Kraft Pulping

Kraft pulps having less than 1 percent screenings were made using the three mixtures. Kraft digestions were also made using the three

mixtures to yield pulps having 25 to 30 percent screenings. These digestions were made to verify the feasibility of using the screened pulp for linerboard and the screenings for corrugating medium. Semichemical kraft and green liquor pulps were also made from mixture A and evaluated for possible use in corrugating medium. The screenings and semichemical pulps were refined to about 350 milliliters (Canadian Standard freeness) in a 12-inch-diameter, single-rotating disk mill and made into handsheets having a basis weight of 26 pounds per 1,000 square feet. Strength development of the screened pulps was in a Valley beater, and handsheets were made and evaluated according to standard TAPPI methods.

Exploratory NSSC Pulping

NSSC pulps with yields of about 75 percent were made from the three mixtures. Additional NSSC digestions of only mixture A were made with increasing amounts of sodium sulfite and sodium carbonate and time at cooking temperature in order to obtain lower yield pulps. The effects of adding increasing amounts of caustic soda to the cooking liquor as the density of the woods in the mixture increased were also determined in another series of NSSC digestions made at the 75 percent yield level. All of these semichemical pulps were refined to about 350 milliliters (Canadian Standard freeness) in a 12-inch-diameter, single-rotating disk mill and made into handsheets having a basis weight of 26 pounds per 1,000 square feet.

Pilot-Scale Kraft Pulping and Bleaching

Three pilot-scale digestions of mixture A were made under the following conditions:

(1) 16 percent active alkali.

(2) 25 percent sulfidity.

(3) 4-to-1 water-to-wood ratio.

(4) 90 minutes to raise the temperature to 170° C.

(5) 90 minutes at 170° C.

Each digestion was blown, and the resulting pulps were washed, screened through a 0.012-inch slotted flat screen, and wet lapped. The pulps were combined before CEDED bleaching, and the composite pulp had a Kappa number of 27.6. A pilot-scale CEDED bleach of the composite kraft pulp was made to produce a bleached market-type pulp.

Results

Properties of Individual Species and Mixtures

The specific gravity, ash, and silica contents of the individual species are given in table 1. The specific gravity ranged from a low of 0.141 to a high of 0.859. Ash contents ranged from 0.18 to 3.73 percent, while silica contents ranged from none to a high of 1.48 percent.

The amounts of the individual species in the three mixtures are given in table 2. The lowest density species was excluded from the mixtures because of the small amount of good fiber in this species. Mixture A contains an even distribution of species, while mixture B is weighted with more of the high-density species, and mixture C is weighted with more of the intermediate-density species. The weighted average specific gravity of the three mixtures is 0.510, 0.667, and 0.544, respectively. As shown in table 3, there were only small differences in the pH and

the amounts of ash, extractives, and lignin in the three mixtures. A larger difference was found in the amount of silica, however, which ranged from 0.04 to 0.28 percent.

Quality of Screened Exploratory Kraft Pulps

As shown in table 4, similar yields and Kappa numbers were obtained from all three mixtures cooked under the same conditions.

There were only small differences in the quality of the fully cooked kraft pulps made from the three mixtures (table 5). The strength properties of these pulps were equal to or better than those of North American hardwood kraft pulps and comparable to previous results found with similar mixtures of tropical hardwoods from both the Philippines and Ghana. The screened pulp from the digestion of mixture C designed to give a high percentage of screenings was only slightly lower in strength than that of the fully cooked kraft pulp made from the same mixture. However, the screened pulps from the digestions of mixtures A and B designed to give high percentages of screenings had considerably lower strength than those of the fully cooked pulps made from the same mixtures. The most severe loss was in bursting strength, which was about 20 percent at 350 milliliters (Canadian Standard freeness).

Quality of Exploratory Semichemical and Screenings Pulps for Corrugating Medium

The conditions and results of the NSSC digestions are given in table 6. As was found with the Philippine and Ghanaian mixtures, the differences between the three Colombian mixtures in their response to

NSSC pulping to 75 percent yield are small. Using mixture A, the addition of 3 percent caustic soda to the NSSC pulping liquor reduced the cooking time at 175° C. from 90 to 70 minutes and increased the spent liquor pH from 8.5 to 9.8. Increasing only the cooking time from 90 to 215 minutes, while cooking mixture A with the same chemical charge used to produce the 75 percent yield pulp, reduced the pulp yield to about 69 percent. Increasing the sodium sulfite to 22 percent, the sodium carbonate to 5.5 percent, and the cooking time at 175° C. to 255 minutes gave a pulp yield of about 66 percent. Reducing the yield further would not be economically practicable because of the excessive amounts of chemical and time at cooking temperature that would be required.

The addition of increasing amounts of caustic soda to the NSSC cooking liquor as the density of the woods in the mixtures increases was shown to be an effective way of obtaining the same yield pulps without changing the cooking time.

The handsheet properties of the semichemical and screenings pulps are given in table 7. Based on these data, it appears that acceptable quality corrugating medium could be made from 75 percent yield NSSC pulps of mixtures A and C, while the pulping conditions for mixture B need to be changed to obtain comparable handsheet properties. Both the lower yield NSSC pulps and the 75 percent yield pulp made with the addition of 3 percent caustic soda to the NSSC pulping liquor had improved handsheet properties in excess of those normally required to produce a good quality corrugating medium on the paper machine. Similar improved handsheet properties were also obtained from the NSSC pulps made from the lower density wood mixtures where caustic soda was added to the cooking liquor.

Handsheet properties of the kraft screenings pulps indicate that all three mixtures would produce acceptable quality corrugating medium. Both the kraft semichemical and the green liquor semichemical pulps at the 73 percent yield level appear to be unacceptable for producing good quality corrugating medium. As the yield of the kraft semichemical pulps was reduced, the handsheet properties increased. However, it was not until a yield of about 59 percent was reached that the handsheet properties approached those of the kraft screenings made from the same wood mixture. This was not unexpected since the kraft semichemical pulp at 59 percent yield has about the same Kappa number as the kraft screenings.

Response to Bleaching and Quality of Bleached Pulp

The conditions and results of the pilot-scale CEDED bleach of the kraft pulp are given in table 8. Bleaching with CEDED gave a bleached pulp with a brightness of 86.0 percent and a viscosity of 10.2 centipoises.

Handsheet properties of both the unbleached and bleached pilot-scale pulps are given in table 9. Compared to the unbleached kraft pulp, the CEDED bleached pulp was 10 to 20 percent lower in bursting and tensile strengths, while the tearing resistance of the CEDED bleached pulp was about the same as the unbleached kraft pulp. Drying of the CEDED bleached pulp on the paper machine caused a loss in all strength properties of about 10 percent.

Even with the above losses, the CEDED bleached pulp was equal to or better than the two bleached kraft market pulps made from North American hardwoods grown in different areas (machine run No. 7156).

Conclusions

(1) The strength properties of the kraft pulps made from all three mixtures were equal to or better than those of North American hardwood kraft pulps.

(2) It appears that acceptable quality corrugating medium could be made from mixtures A and C cooked to 75 percent yield by the NSSC process. Mixture B would require modification of the cooking conditions to obtain comparable handsheet properties.

(3) Improved handsheet quality can be obtained by the addition of caustic soda to the NSSC pulping liquor and/or by reducing pulp yield. Reducing the NSSC pulp yield to less than 66 percent would not be economically practicable because of the excessive amounts of chemical and time at cooking temperature that would be required.

(4) The concept of using only one high-yield kraft pulping process to produce 25 to 30 percent screenings for use in the manufacture of corrugating medium and screened pulp for use in linerboard was verified as being feasible.

(5) Semichemical kraft and green liquor pulps at 73 percent yield are deficient in the handsheet properties considered essential for the production of good quality corrugating medium.

(6) Semichemical kraft pulp, with a Kappa number equal to that of the kraft screenings, had handsheet properties comparable to those of kraft screenings. However, the total yield advantage was small; the semichemical kraft pulp had a yield of 59 percent, while the combined yield of the screenings and screened pulp was 55 percent.

(7) Kraft pulp from a mixture of Colombian hardwoods can be bleached using CEDED to provide a strong market grade of pulp.

Table 1.--Specific gravity, ash, and silica content of 18 Colombian hardwoods

No.	Species: Common name	Species: Botanical name	Specific gravity[1/]	Ash[2/]	Silica[2/]
				Pct	Pct
1	Peine mono	Apeiba apera	0.141	3.55	<0.01
2	Ceiba	Ceiba pentandre	.225	3.73	< .01
3	Yarumo	Cecropia sp.	.250	1.71	.02
4	Cirpo	Pourouma sp.	.369	.76	< .01
5	Chingale	Jacaranda copaia	.372	.58	< .01
6	Dormilon	Vochysia ferruginea	.447	.82	.02
7	Sande	Brosimum utile	.494	.51	.01
8	Sangretoro	Virola sebifera	.511	.33	< .01
9	Arenillo	Catostemma alstonii	.536	1.26	< .01
10	Canelo	Nectandra sp.	.546	.18	< .01
11	Perillo negro	Couma macrocarpa	.547	.40	< .01
12	Casaco	Hieronyma sp.	.603	.55	< .01
13	Carbonero	Enterolobium schomburgkii	.634	.75	< .01
14	Chocho	Ormosia paraensis	.671	.29	.01
15	Carreto	Aspidosperma sp.	.692	.62	< .01
16	Lecheperra	Helicostylis tomentosa	.785	1.10	.03
17	Tamarindo	Dialium guianense	.823	1.82	1.48
18	Caimo	Pouteria sp.	.859	.95	.55

1/ Dry weight, green volume basis.
2/ Moisture-free wood basis.

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Table 2.--Composition of 3 mixtures of 17 Colombian hardwoods

Species[1/]	Specific gravity range	Mixture composition[2/]		
		A	B	C
		Pct	Pct	Pct
2 - 3	0.225 - 0.250	16.67	2	4
4 - 5	.369 - .372	16.67	4	8
6 - 8	.447 - .511	16.67	9	20
9 - 11	.536 - .547	16.67	15	40
12 - 14	.603 - .671	16.67	20	20
15 - 18	.692 - .859	16.67	50	8

1/ See table 1 for names of the individual species.
2/ Moisture-free wood basis.

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Table 3.--Chemical analysis of Colombian chip mixtures

Mixture	pH	Ash[1/]	SiO_2[1/]	Extractives[1/]			Lignin[1/]
				Ethyl ether	Alcohol benzene	Hot water	
		Pct	Pct	Pct	Pct	Pct	Pct
A	5.71	0.94	0.06	0.33	3.84	3.79	28.71
B	5.81	.91	.28	.34	3.15	3.15	28.60
C	5.59	.68	.04	.31	3.66	3.66	29.51

1/ Moisture-free wood basis.

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Digestion No.	Active alkali[2]	Cooking temperature	Time-- To temperature	Time-- At temperature	Black liquor NaOH (Na_2O)	Black liquor Na_2S (Na_2O)	Yield[2] Total	Yield[2] Screenings	Kappa number Screened or whole pulp	Kappa number Fiberized screenings
	Pct	°C	Min	Min	G/l	G/l	Pct	Pct		
				MIXTURE A						
6078X	16.0	170	90	90	4.6	6.9	46.9	1.2	24.5	--
6088X	16.0	170	90	15	7.7	6.8	54.6	27.6	67.5	83.0
6124X	14.0	170	60	15	4.3	7.6	58.8	--	87.0	--
6119X	14.0	170	60	0	7.1	7.9	65.8	--	150.0	--
6089X	10.0	160	80	0	1.7	4.3	69.0	--	162.0	--
6095X	10.0	160	55	0	1.8	5.3	72.6	--	172.0	--
[3] 6096X	17.5	160	55	0	0	35.0	72.5	--	170.0	--
				MIXTURE B						
6081X	16.0	170	90	90	5.3	6.6	47.5	.4	23.3	--
6083X	16.0	170	90	15	9.5	7.4	53.6	19.0	56.7	80.1
				MIXTURE C						
6080X	16.0	170	90	90	5.1	6.5	46.7	.7	23.4	--
6084X	16.0	170	90	15	8.3	7.2	52.4	21.2	55.3	98.8

1/ Unless otherwise noted, the following constant conditions were used: 25.0 pct sulfidity and 4-to-1 water-to-wood ratio.

2/ Moisture-free wood basis.

3/ Green liquor at 100 pct sulfidity based on active alkali.

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Digestion No.	Pulp properties				Handsheet properties					
	Kappa number	Average fiber length	Coarseness	Fibers per gram	Freeness (Canadian Standard)	Beating time	Burst factor	Tear factor	Breaking length	Apparent density
		Mm	Mg/100 m	$x10^{-5}$	Ml	Min			Km	G/cm^3
					MIXTURE A					
6078X	24.5	1.12	11.4	90.2	670	0	22.0	124.0	5.6	0.52
					550	16	48.5	125.0	8.8	.58
					350	30	68.0	124.5	11.0	.66
6088X	67.5	--	--	--	725	0	11.5	65.5	3.7	.47
					550	24	40.0	88.5	11.3	.59
					350	43	55.0	103.0	11.0	.62
					MIXTURE B					
6081X	23.3	1.18	12.9	77.3	690	0	14.6	85.6	4.1	.45
					550	23	55.0	133.0	7.3	.55
					350	45	61.0	140.5	9.2	.61
6083X	56.7	--	--	--	730	0	8.5	61.5	2.5	.45
					550	29	31.0	118.0	6.5	.51
					350	47	49.0	129.0	8.0	.55
					MIXTURE C					
6080X	23.4	1.23	13.9	70.3	675	0	20.0	113.8	5.1	.51
					550	22	47.0	143.0	8.4	.58
					350	42	65.0	140.0	10.4	.64
6084X	55.3	--	--	--	730	0	12.5	80.5	3.4	.47
					550	32	45.0	133.0	8.4	.57
					350	55	61.0	127.5	9.7	.61

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Table 6.--NSSC pulping[1/] of Colombian hardwood mixtures

Chip mixture	Digestion No.	Chemicals charged[2/]			Time at 175° C	Spent liquor		Yield[2/]
		Na_2SO_3	Na_2CO_3	NaOH		Na_2SO_3	pH	
		Pct	Pct	Pct	Min	G/l		Pct
A	2536Y	16.0	4.0	0	90	15.0	8.5	74.0
B	2541Y	16.0	4.0	0	120	14.6	8.6	75.2
C	2540Y	16.0	4.0	0	105	13.8	--	74.3
A	2545Y	16.0	4.0	3.0	70	13.1	9.8	73.2
(2)	2544Y	16.0	4.0	2.0	75	16.6	9.4	74.0
(3)	2543Y	16.0	4.0	1.0	75	14.4	8.6	74.2
(4)	2542Y	16.0	4.0	0	45	17.8	7.9	74.4
A	2546Y	16.0	4.0	0	215	7.0	8.8	69.2
A	2548Y	22.0	5.5	0	255	12.9	9.3	66.1

1/ Constant conditions used were 3.5-to-1 water-to-wood ratio, 15-min presteaming at 15 lb/in^2g, and 120-min rise from 80° to 175° C.
2/ Contains 14 species with specific gravity at or less than 0.692.
3/ Contains 10 species with specific gravity at or less than 0.547.
4/ Contains 4 species with specific gravity at or less than 0.372.

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Table 7.--Handsheet properties of neutral sulfite, kraft, and green liquor semichemical pulps and kraft screenings made from mixtures of Colombian hardwoods

Chip mixture	Pulping process	Digestion No.	Pulp yield	Freeness (Canadian Standard)	Basis weight	Thickness	Burst factor	Tear factor	Breaking length	Apparent density	Ring crush	Concora
			Pct	Ml	Lb/1,000 ft^2	Mils			M	G/cm^3	Lb	Lb
					EFFECT OF MIXTURE COMPOSITION							
A	NSSC	2536Y	74.0	350	26.0	10.6	21.5	60.6	4,785	0.42	55.4	56.8
B	.....do.....	2541Y	75.2	370	26.2	11.2	19.1	59.7	4,380	.40	50.0	46.6
C	.....do.....	2540Y	74.3	325	26.3	10.7	20.8	56.6	4,540	.43	57.8	58.4
A	Kraft screenings	6088X	27.0	345	27.2	9.6	37.6	97.0	7,060	.49	66.2	71.2
B	.....do.....	6083X	19.0	375	26.9	10.2	28.9	71.5	5,580	.46	58.4	59.8
C	.....do.....	6084X	21.2	360	26.8	8.4	38.6	109.6	6,810	.55	70.8	67.2
					EFFECTS OF WOOD DENSITY AND CAUSTIC ADDITION							
A	NSSC	2536Y	74.0	350	26.0	10.6	21.5	60.6	4,785	.42	55.4	56.8
A	NSSC + 3% NaOH	2545Y	73.2	340	26.5	9.5	29.2	67.4	5,895	.48	63.8	66.0
(1)	NSSC + 2% NaOH	2544Y	74.0	380	26.7	9.8	26.4	70.1	5,540	.47	64.8	62.0
(2)	NSSC + 1% NaOH	2543Y	74.2	355	25.9	9.7	28.1	64.7	5,830	.46	66.4	64.2
(3)	NSSC	2542Y	74.4	380	26.1	8.9	32.5	67.1	6,485	.51	72.4	65.6
					EFFECTS OF YIELD							
A	.....do.....	2536Y	74.0	350	26.0	10.6	21.5	60.6	4,785	.42	55.4	56.8
A	.....do.....	2546Y	69.2	345	27.3	9.8	27.2	78.0	5,925	.48	67.0	67.6
A	.....do.....	2548Y	66.1	350	28.2	10.1	30.1	70.4	6,140	.48	68.6	75.6
A	Kraft	6124X	58.8	340	25.9	9.6	34.8	111.2	6,795	.47	44.4	69.4
A	.....do.....	6119X	65.8	350	26.2	10.5	22.6	75.6	5,080	.43	39.6	55.0
A	.....do.....	6089X	69.0	340	26.3	10.9	16.9	59.5	4,115	.42	44.4	47.0
A	.....do.....	6095X	72.6	365	26.5	11.7	13.9	42.6	3,325	.39	41.0	38.8
A	Green liquor	6096X	72.5	335	26.5	11.3	18.1	54.9	4,005	.41	50.2	48.0

1/ Contains 14 species with specific gravity at or less than 0.692.
2/ Contains 10 species with specific gravity at or less than 0.547.
3/ Contains 4 species with specific gravity at or less than 0.372.

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of Colombian hardwoods and bleached kraft market pulps from North American hardwoods

Kraft pulp type	Handsheet properties						Pulp properties	
	Freeness (Canadian Standard)	Beating time	Burst factor	Tear factor	Breaking length	Apparent density	Brightness	Viscosity
	Ml	Min			Km	G/cm^3	Pct	cP
Unbleached	625	0	27.0	122.2	6.3	0.57	--	--
	550	10	45.0	117.0	8.5	.61	--	--
	350	25	63.0	108.0	10.4	.67	--	--
Bleached--CEDED	575	0	19.0	109.0	4.2	.58	86.0	10.2
	550	5	28.0	114.0	5.4	.61	--	--
	350	24	53.0	118.0	8.1	.68	--	--
Bleached--CEDED (paper machine dried)	615	0	13.6	94.2	3.4	.56	--	--
	550	12	23.5	123.0	4.9	.60	--	--
	350	32	45.5	113.0	7.5	.67	--	--
Bleached market pulp (Southern U.S. hardwoods--dried)	680	0	10.6	99.6	3.0	.55	89.4	11.2
	550	18	35.5	117.0	6.4	.64	--	--
	350	35	55.0	110.0	8.1	.69	--	--
Bleached market pulp (eastern Canadian hardwoods--dried)	565	0	12.1	72.1	2.7	.60	88.9	11.2
	550	3	14.0	73.0	3.1	.61	--	--
	350	36	37.0	81.0	6.1	.71	--	--

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